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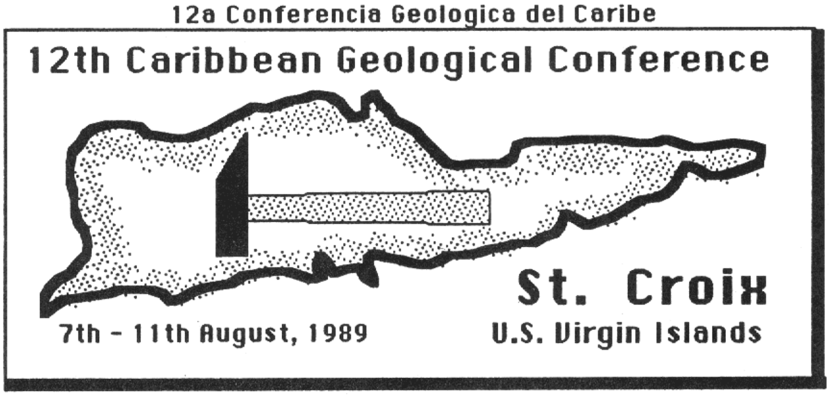

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SEDIMENTARY ROCKS OF THE SANTA CRUZ OPHIOLITE, GUATEMALA - A PROTO-CARIBBEAN HISTORY

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ABSTRACT

The Santa Cruz ophiolite of eastern Guatemala includes sedimentary rocks deposited in the Cretaceous proto-Caribbean ocean. Several conclusions, noted below, are based on preliminary study of these strata.

Intra-basalt chert nodules were deposited during Upper Valanginian/Aptian eruptive activity at the proto-Caribbean spreading center. This oceanic crust was partially blanketed in the Aptian/Albian by upward coarsening volcaniclastic debris derived from the proto-Antillean Island Arc during collision of the western proto-Caribbean with thick Pacific plateau basalt. Chert interbeds date off-axis (seamount?) basaltic eruptions as Albian in age. Argillite melange, possibly Cenomanian in age, formed in an accretionary prism along the leading edge of the advancing Pacific crust. An organic-rich, deep water limestone appears to have been deposited during the widespread Cenomanian Oceanic Anoxic Event.

PURPOSE

With this paper, I propose to accomplish the following:

1) To make available results of a geological reconnaissance originally presented as an unpublished doctoral dissertation (Rosenfeld, 1981.)
2) To place the Santa Cruz ophiolite into the most recent plate tectonic framework.
3) To suggest avenues for further study.

INTRODUCTION

Recent plate tectonic models of the Caribbean (Pindell and Barrett, in press; Donnelly, 1989; Burke, 1988) agree that a "proto-Caribbean" ocean was formed by seafloor spreading between North and South America from the Late Jurassic to the Late Cretaceous. This western arm of the Atlantic Ocean was subsequently consumed beneath a vast slab of thickened Pacific ocean crust ("plateau basalt") which now underlies the oceanic basins of the Caribbean Sea.

Our knowledge of the proto-Caribbean is derived from pieces preserved in ophiolitic terranes obducted during collision of the advancing Pacific crust with continental promontories on the Americas Plate (Yucatan, the Bahamas and northwestern South America).

This paper discusses some aspects of the Santa Cruz ophiolite of eastern Guatemala, a well preserved fragment of the proto-Caribbean which was obducted onto the cratonic Yucatan Block in the Late Campanian. Sedimentary units of the ophiolite have been spared the intense metamorphism, tectonic dismemberment and deep erosion suffered by related ophiolitic fragments smeared along the Motagua-Polochic strike-slip fault zones in Guatemala. These preserved strata provide tantalizing glimpses of proto-Caribbean history.

A more complete description of the Santa Cruz ophiolite, including petrographic, chemical and paleontologic analyses, is found in a doctoral dissertation available from the State University of New York at Binghamton (Rosenfeld, 1981).

REGIONAL SETTING

The Santa Cruz ophiolite underlies the Sierra de Santa Cruz (Figure 1); an east-trending range of jungle covered hills 90 kilometers long and 15 kilometers wide with elevations reaching 1,000 meters. The southern edge of the massif flanks the Izabal pull-apart basin in the Polochic Fault Zone. Post-Middle Miocene left-lateral displacement of about 130 kilometers has been postulated for the Polochic Fault System through palinspastic reconstruction of geological and geomorphological features (Burkart et al, 1987).

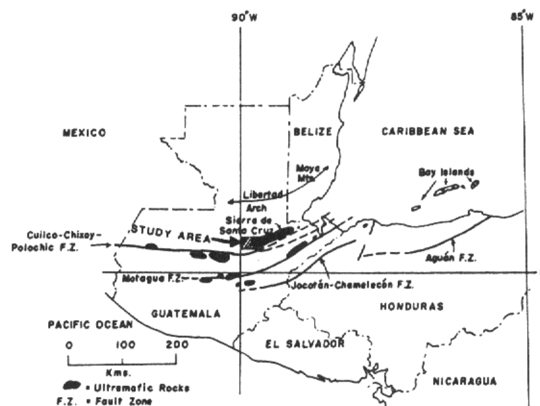

Figure 1 – Major Fault Zones & Ultramafic Exposures of Northern Central America

To its west, north and east, the ophiolite is thrusted over Late Campanian synorogenic turbidite flysch of the Sepur Formation. The Sepur and underlying Cretaceous carbonates are also exposed in windows through the allochthon (Figures 2 and 3). Crystalline basement is a pre-Pennsylvanian gneiss exposed southwest of the ophiolite along the Polochic Fault (Bonis, 1967). The

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EXPLANATION

Qal = Quaternary Alluvium

Allochthonous Units

CRETACEOUS
- Ktz = Tzumuy Fm. - chert, gray wacke, breccia
- Kj = Jolomax Fm. - scaly argillite melange
- b = Pillow & Massive basalt
- g = Gabbro & diabase

Us = Massive & serpentinite melange

Autochthonous Units

CRETACEOUS
- KTs = Sepur Fm. - flysch
- Kc = Coban & Campur Fms. - limestone

SYMBOLS

- Thrust fault - teeth on hanging wall
- Strike slip fault
- U/D Dip slip fault
- Generalized bedding
- Stratigraphic contact
- Anticlinal axis

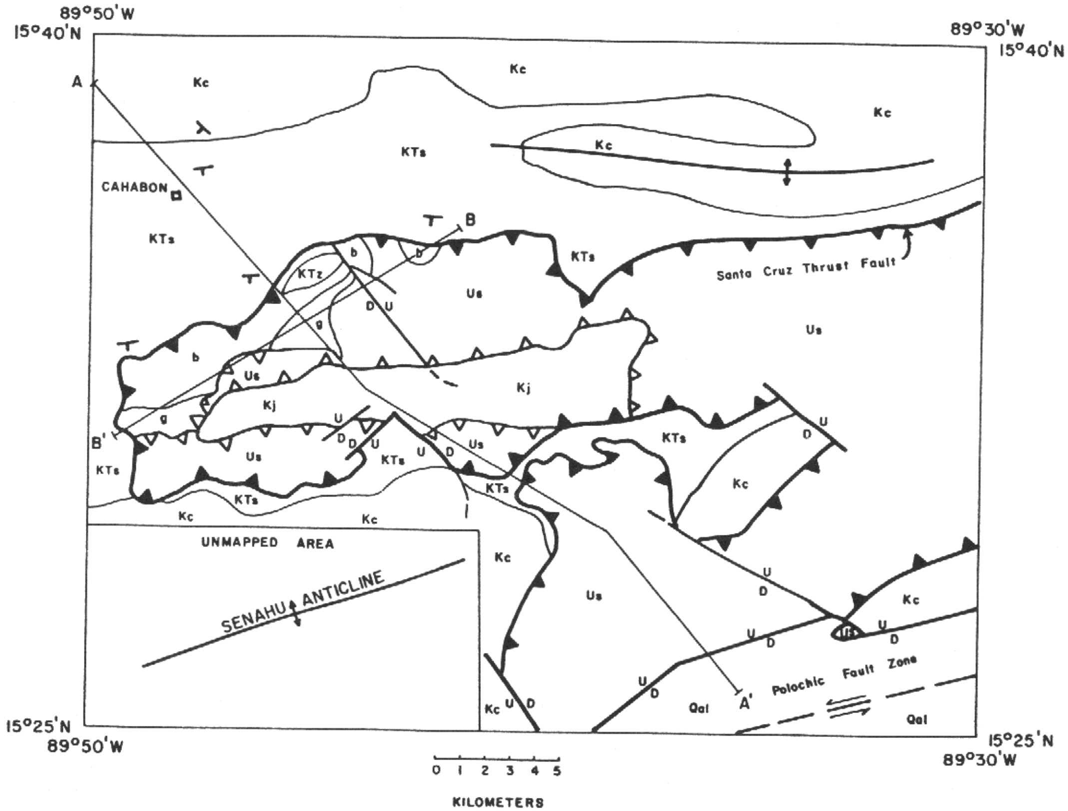

FIG. 2 - GEOLOGIC SKETCH MAP OF THE WESTERN SIERRA DE SANTA CRUZ

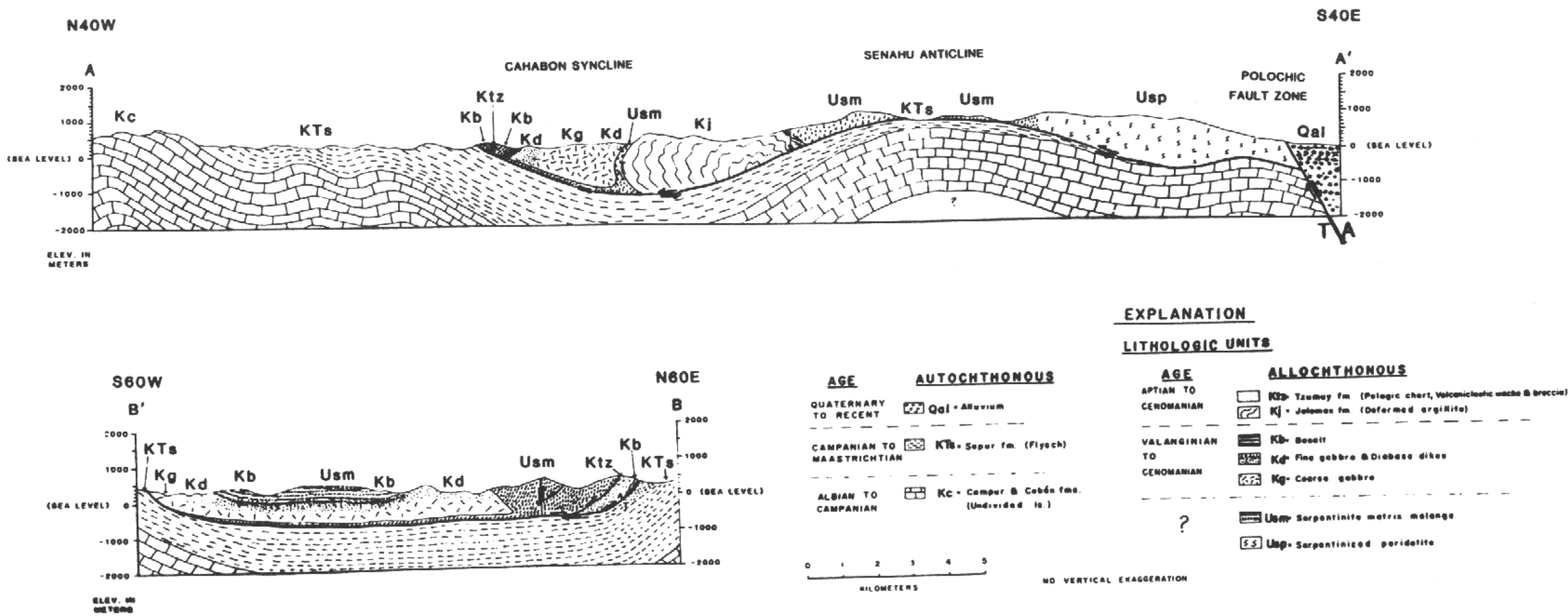

FIGURE 3 GEOLOGIC SECTIONS (LOCATIONS SHOWN ON FIG. 2)

complete Pennsylvanian to Campanian autochthonous sedimentary sequence (Figure 4) crops out in the eroded core of the Senahu Anticline on the western edge of the Sierra de Santa Cruz (Unmapped Area in Figure 2).

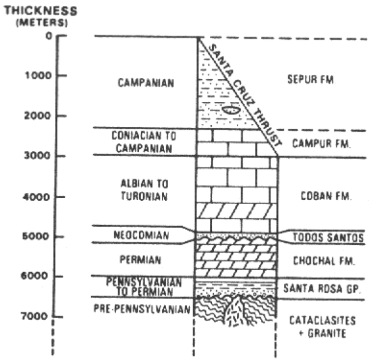

FIG. 4 THE AUTOCHTHONOUS SECTION

The basal decollement of the allochthon is the Santa Cruz Thrust. The translation of the ophiolite slab onto a Campanian turbidite fan occurred as a gravity slide derived from the south (Wilson, 1974, Rosenfeld, 1981).

THE OPHIOLITE

Crystalline Rocks

The ophiolite consists of a layered sequence of serpentinized harzburgite, gabbro, diabase, and hydrothermally altered basalts, whose mafic rocks display typical MORB compositions. Ultramafic cumulates were found in stream boulders, and minor plagiogranite bodies occur within the upper level gabbro and serpentinite melange. The extensive serpentinite melange also encloses blocks of gabbro and amphibolite, as well as disrupted dikes of coarse gabbro, diabase and pyroxenite.

Copper mineralization occurs within basalt and diabase altered to greenschist facies mineralogies. Ore deposition took place in an oceanic hydrothermal system (Peterson and Zantop, 1980; Rosenfeld, 1981; Wilson and Peterson, 1989). Over two million tons of chalcopyrite bearing ore were processed in the 1970's at the Oxec Mine.

Sedimentary Rocks

Intrabasalt Cherts-

Interpillow chert nodules in the lowermost basalts have been dated as Upper Valanginian-Aptian (E. Pessagno, pers. comm.) indicating that seafloor spreading was active at that time. Higher level basalts enclose dark green to black chert beds dated as Berriasian(?)-Albian (P. Whelan-Helwig, pers. comm.). The Albian age is more likely, based on stratigraphic position. Basalts enclosing the younger cherts are less metamorphosed than their deeper counterparts (zeolite vs. greenschist mineralogy), and are amygdular while the older are not. The indication is that eruption of the upper basalts occurred at relatively shallow water depths, and one may speculate that Albian eruptions occurred at an off-axis seamount.

Supra(?)-basalt Limestone-

A single outcrop of black, finely laminated limestone was found in contact with weathered pillow basalt. Coarser laminae contain concentrations of planktonic foraminifera, radiolaria, calcareous nannoplankton and volcanic detritus (euhedral plagioclase, devitrified glass). An analyzed sample contained 1.7% Total Organic Carbon (J. Clendening pers. comm.). Pyrite is abundant in the rock matrix. The age of this sample is probably Cenomanian, (E. Pessagno, L. Balcells-Baldwin, and R. White; see Appendix 1).

The fossil assemblage indicates a purely marine, deep water environment of deposition and the absence of keeled foraminifera suggests that anoxia of the deeper water may have suppressed the deeper water genera which should be abundant in this environment (Jarvis et. al., 1988, p. 87-94.) The high organic carbon content and non-bioturbated lamination of the limestone support this interpretation. Rare benthonic foraminifera and volcanic detritus in some laminae suggest deposition from low energy debris flows originating on a volcanic seamount in the area.

Supra-basalt Volcaniclastics (Tzumuy Formation)-

The lower basalts of the ophiolite are overlain by a 500 meter thick coarsening-upward sequence of bedded chert, turbiditic graywacke and clast supported volcaniclastic breccia of the Tzumuy Formation (Figure 5). These rocks are quite indurated, in contrast to the autochthonous Sepur Formation. Outcrop samples were devoid of usable fossils, but a float fragment yielded a radiolarian age of Aptian-Albian (P. Whelan-Helwig, pers. comm.).

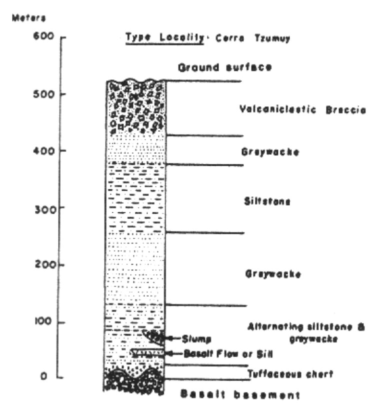

Figure 5- Tzumuy fm. Stratigraphic Section

The volcanic component of the Tzumuy includes pumice shards and euhedral plagioclase grains in the basal cherts. Sandstones contain zoned plagioclase, trachytic textured lithic clasts of dacitic to rhyolitic aspect, and up to 5% quartz presumed to be of volcanic origin. Subangular granule to cobble breccias contain over 95% "arc type" volcanic clasts. A non-MORB, possibly Primitive Island Arc origin has been proposed for these rocks (T. Donnelly, pers. comm.). Although chemistry was not performed on individual volcanic fragments, bulk chemical analyses of the sandstones yielded intermediate range SiO_2 values of 55% to 57%, supporting the interpretation of a volcanic arc provenance for this unit.

This coarsening-upward volcaniclastic sequence, deposited on Aptian oceanic crust, suggests that spreading in this part of the proto-Caribbean occurred near an arc (Figure 6A). It may also be argued that no deep, sediment-trapping trench existed between the arc and this segment of oceanic crust in the Aptian. These suppositions are consistent with the existence of an Aptian Primitive Island Arc at the leading edge of the Pacific plateau basalt (the proto-Antillean Arc of Donnelly, op cit) which "matured" into an intra-oceanic island arc subduction complex during the Albian or Cenomanian as the advancing Pacific crust overrode the western proto-Caribbean (Figure 6B).

<u>Scaly Argillite (Jolomax Formation)-</u>

Sedimentary melange underlies a large area in the core of the ophiolite. Abundant, randomly oriented shear surfaces and mineralized fractures disrupt rarely discernable bedding. The rock is thoroughly metamorphosed in the prehnite-pumpellyite facies.

The fresh rock is dark green to black, weathering to an intense red through oxidation of abundant matrix pyrite. Tightly folded and dismembered chert and volcanic sand laminae comprise a minute percentage of the overall argillite. Included in the melange are large blocks of serpentinite, minor clumps of pillow basalt and small, angular fragments of micritic limestone and chert. Radiolaria occur in the argillaceous matrix but no usable dates have been obtained from the limited original collection (P. Whelan-Helwig, pers. comm.).

The Jolomax Formation may be an accretionary wedge deposit formed at the leading edge of the advancing Pacific crust (Figure 6B). In the absence of age data, the dark color and abundance of pyrite tenuously suggest a dysoxic to anoxic environment of deposition and possible correlation of this unit with the Cenomanian supra-basalt limestone.

DISCUSSION

It is presumptuous to construct a history of the western proto-Caribbean using a few poorly dated sedimentary rocks from a small area of eastern Guatemala. That said, I believe that the Santa Cruz ophiolite contains evidence of Aptian seafloor spreading, Albian-Cenomanian off-axis seamount eruptions, Aptian proto-Antillean island arc activity, and the accumulation of an accretionary prism on the inner wall of a Cenomanian trench. Further speculation links the Cenomanian paleoceanography of the proto-Caribbean to the widespread contemporaneous Oceanic Anoxic Event.

Northward obduction of the Jolomax accretionary prism and a contiguous slab of the proto-Caribbean lithosphere onto the leading edge of Yucatan occurred in the Late Campanian, followed immediately by a northward gravity slide of the allochthon into the Sepur foreland basin. The area was folded in the Paleogene by transpression of Chortis against the southern margin of Yucatan. Neogene strike-slip displacement in the Polochic Fault Zone sliced off and removed to the east the southern continuation of the Santa Cruz ophiolite.

RESEARCH OPPORTUNITIES

This paper highlights an obvious need for further work in the Santa Cruz ophiolite, and in the surrounding flysch where studies may clarify the framework of ophiolite emplacement and the complex interactions of the Yucatan Block, the Antillean Arc and Chortis. I have chosen here to concentrate on the allochthonous sedimentary rocks since they are windows through which proto-Caribbean history may be viewed. Detailed study of these strata would test hypotheses proposed in this paper, and would most certainly lead to more rigorously derived conclusions.

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The original fieldwork and dissertation could not have been possible without the guidance and support of T. W. (Nick) Donnelly and the State University of New York at Binghamton. I owe special thanks to Peter Marsh, geologist and mining engineer, for introducing me to the area and arranging support for the fieldwork. Many colleagues have provided invaluable insights and encouragement. Among others, I would like to thank Fred Nagle, Steve Barrett, Burke Burkart, Peter Muller, Kevin Burke, and the paleontologists cited in the text. Thanks are also due to the management of Amoco Production Company for their continued support and permission to make this contribution.

APPENDIX I

<u>Supra(?)-basalt Limestone Fossil Determinations</u>

<u>from E. A. Pessagno</u>
- <u>Hedbergella delrioensis</u> (Carsey)
- <u>Hedbergella planispira</u> (Tappan)
- <u>Globigerinelloides</u> sp.
- <u>Rotalipora evoluta</u> (Sigal)

<u>from L. Balcells-Baldwin</u>
- <u>Hedbergella delrioensis</u>
- <u>Hedbergella planispira</u>
- <u>Heterohelix</u> sp.
- <u>Marginulinopsis</u>
- <u>Lenticulina</u>

<u>from R. J. White</u>
- <u>Watznaueria barnesae</u>
- <u>Braarudosphaera africana</u>
- <u>Nannoconus truitti</u>

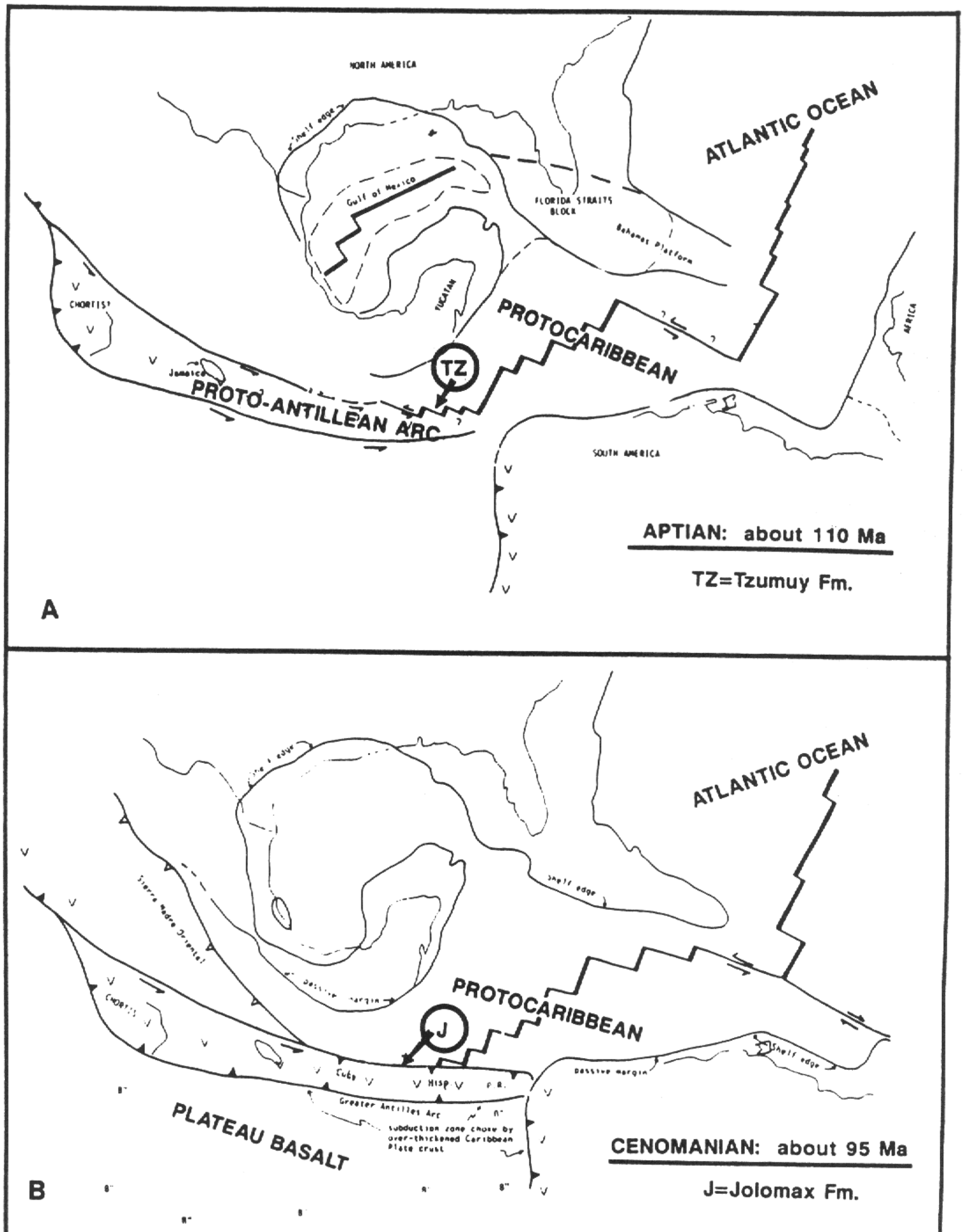

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FIGURE 6 : PROTOCARIBBEAN RECONSTRUCTIONS

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